REPORT NO. FAA-FS-600-8

EVALUATION OF Approach Procedures for ILS Back Course with Glide Slope

Allan W. Hunting

July 1972
FINAL REPORT

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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Flight Standards Service
Washington, D. C. 20591

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TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-FS-600-8		

4. Title and Subtitle	5. Report Date / 6. Performing Organization Code
Evaluation of Approach Procedures for ILS Back Course with Glide Slope	5. Report Date: July 1972 6. Performing Organization Code: FS-640
7. Author(s): Allan W. Hunting	8. Performing Organization Report No.: FAA-FS-600-8
9. Performing Organization Name and Address: Standards Development Branch, FS-640 National Flight Inspection Division Box 25082 Oklahoma City, Oklahoma 73125	10. Work Unit No.: 11. Contract or Grant No.: 13. Type of Report and Period Covered: FINAL TECHNICAL REPORT
12. Sponsoring Agency Name and Address: Department of Transportation Washington, D. C. 20591	14. Sponsoring Agency Code: DOT

15. Supplementary Notes

16. Abstract

An operational evaluation was performed to compare ILS back course approaches with front course approaches in an effort to determine flyability problems associated with back course ILS with glide slope and the appropriate obstacle clearances to be applied. 32 simulated approaches were flown in the B720 flight simulator. 63 hooded approaches were flown in 6 different aircraft. Facility and airborne systems included Back and Front courses; Localizer only and Localizer with Glide Slope; Normal and Reverse course sensing; and all were flown using raw ILS data for guidance. A questionnaire was filled out on each subject pilot at the end of his runs. Heights above touchdown at which ILS guidance became unusable were computed from simulator tracings and data logs. It was found that the established ILS obstacle clearance criteria for front course ILS approaches with glide slope is adequate for back course approaches with glide slope.

17. Key Words	18. Distribution Statement
ILS Approaches Instrument Procedures Approach Procedures Precision Approach Back Course Approach	Distribution Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	34	

Form DOT F 1700.7 (8-69)

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July 1972

INTRODUCTION

In 1969 the Minneapolis-St. Paul Airports Commission installed glide slopes in conjunction with back course localizer approaches serving 11R and 22 on Minn.-St. Paul International Airport. The non-standard installation was intended as an aid to noise abatement by furnishing vertical guidance for approaches under VFR conditions.

The facilities were subsequently flight checked and commissioned by the FAA for VFR use. A questionnaire issued in a letter to airmen solicited comments from pilots as to the desirability of using the facilities under IFR conditions. The majority of the responses favored IFR use of the installations. The few who were opposed expressed concern with weather minimums to be authorized and potential pilot disorientation resulting from non-standard use of the ILS cross-pointer.

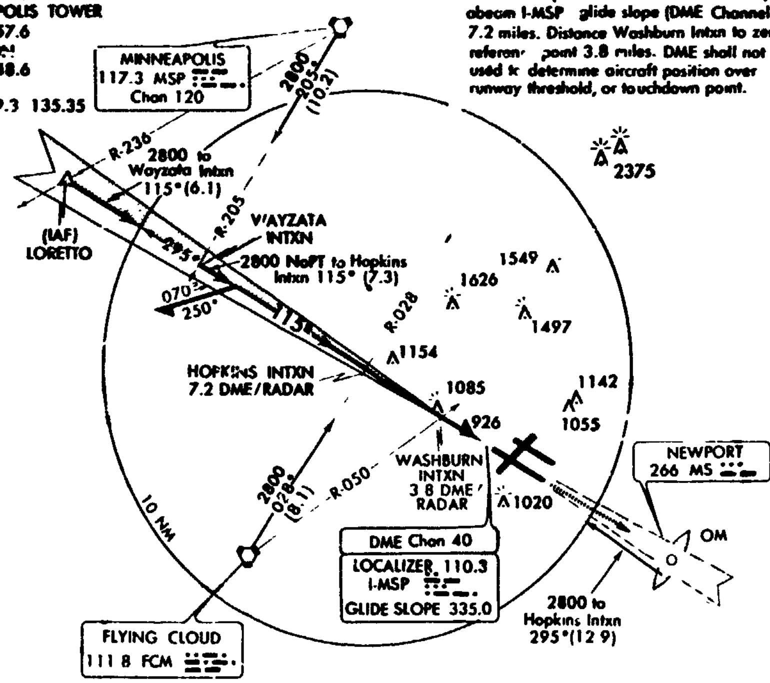
As a result of the questionnaire data and an additional survey of user opinion, CE-200 requested authorization for use of the glide slope facilities during IFR conditions. IFR use was approved, specifying minima no less than "localizer only". The authorization further stated that Flight Standards would conduct an operational evaluation of these procedures to determine obstacle clearance standards for this type facility.

Each of the two back course procedures uses the same localizer transmitters serving the front course approaches. Marker beacons had not been installed for the procedures at the time of this evaluation, but have since been provided. Both runways have REILs and HIRLs. See approach plates, Pages v & vi.

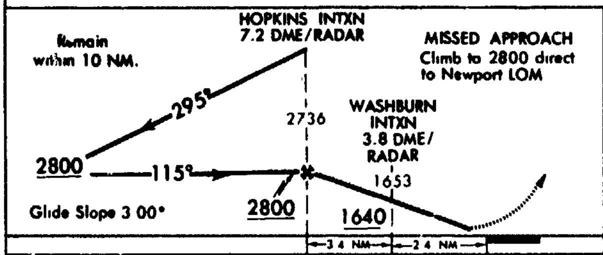
ILS BC RWY 11R — MINNEAPOLIS-ST P[AUL] INTL (WOLD-CHAMB[ERL]AIN FIELD) — AL-264 (FAA) — MINNEAPOLIS, MINNESOTA

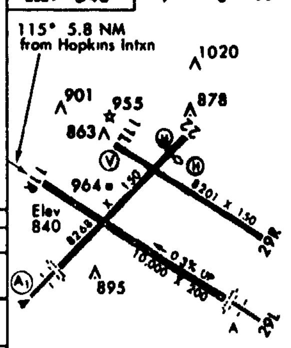
MINNEAPOLIS APPROACH CONTROL
120.0 335.5
MINNEAPOLIS TOWER
118.7 257.6
GND CON
121.9 348.6
ASR
ATIS 109.3 135.35

Dual VOR receivers, DME or Radar required. Distance Hopkins Intxn to zero reference point abeam I-MSP glide slope (DME Channel 40) 7.2 miles. Distance Washburn Intxn to zero referen[ce] point 3.8 miles. DME shall not be used to determine aircraft position over runway threshold, or touchdown point.



BACK COURSE/GLIDE SLOPE





CATEGORY	A	B	C	D
S-ILS 11R	1160/40 320 (400-¾)			1160/50 320(400-1)
S-LOC 11R	1160/40 320(400-¾)			1160/50 320 (400-1)
CIRCLING	1360-1 520(600-1)		1320-1½ 520 (600-1½)	1400-2 560 (600-2)

Inoperative table does not apply to REIL Rwy 11R.

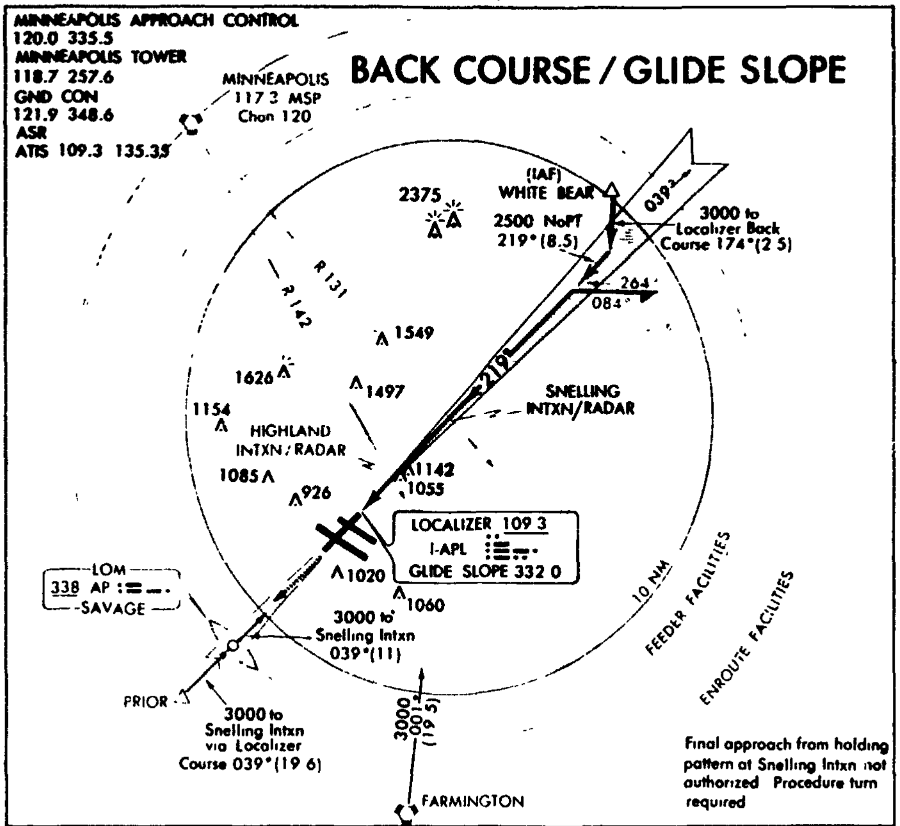
REIL Rwys 11R, 22 and 29R
HIRL Rwys 4-22, 11L-29R and 11R-29L

INTXN to Missed Approach 5.8 NM					
Knots	70	100	125	150	165
Min Sec	4 58	3·29	2.47	2·19	2 07

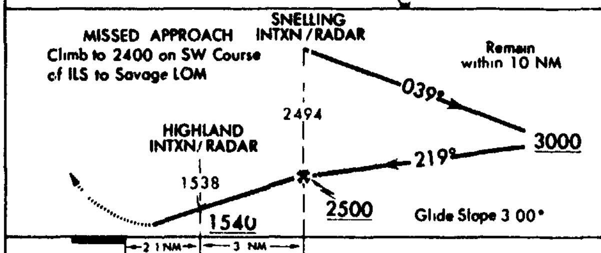
ILS BC RWY 11R — 44°53'N - 93°13'W — MINNEAPOLIS, MINNESOTA
29 APRIL 1971 — MINNEAPOLIS-ST PAUL INTL (WOLD-CHAMBERLAIN FIELD)

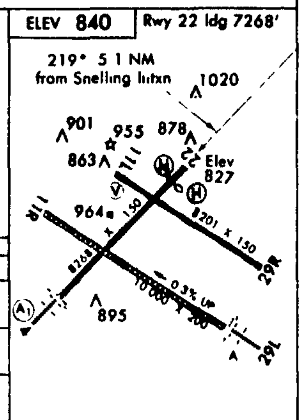
ILS BC RWY 22

MINNEAPOLIS-ST PAUL INTL (WOLD-CHAMBERLAIN FIELD)
AL-264 (FAA)
MINNEAPOLIS, MINNESOTA



Final approach from holding pattern at Snelling Intxn not authorized Procedure turn required





CATEGORY	A	B	C	D
S-ILS 22	1320-¾ 493(500-¾)			1320-1 493(500-1)
S-LOC 22	1320-¾ 493 (500-¾)			1320-1 493(500-1)
CIRCLING	1360-1 520(600-1)		1360-1½ 520(600 1½)	1400-2 560 (600-2)

Dual VOR receivers or Radar required
Inoperative table does not apply to REIL Rwy 22
Sliding scale not authorized
Air carriers will not reduce landing visibility due to local conditions Rwy 22

REIL Rwys 11R, 22 and 29R
HIRL Rwys 4-22,11L-29R and 11R-29L

INTXN to Missed Approach 5 1 NM

Knots	70	100	125	150	165
Min Sec	4 22	3 04	2 27	2 02	1 51

ILS BC RWY 22

25 APRIL 197

44°53'N - 93°13'W
MINNEAPOLIS MINNESOTA
MINNEAPOLIS-ST PAUL INTL (WOLD-CHAMBERLAIN FIELD)

PUBLI NOS NOAA TO IACC SPECIFI

STATEMENT OF THE PROBLEM

The non-standard ILS back course system involves flyability problems not experienced on the front course because of two factors:

1. The cross-pointer on the ILS indicator presents "normal" glide slope sensing and "reverse" localizer sensing, except in aircraft equipped with Flight Director Systems or localizer sensing switch capability. Simultaneously flying toward the glide slope needle but away from the localizer needle requires an abnormal interpretation of the ILS indicator.

2. Use of the front course localizer antenna for the back course approach results in a "squeezed" back-course, approximately 14% as wide as the front course at comparable distances from the approach ends of the runways.

At some point during the final approach, flyability can be expected to deteriorate as the pilot copes with both "abnormal" instrument interpretation and increased CDI sensitivity. Data are needed to develop obstacle clearance standards and identify the point at which the system is unflyable and the pilot should pick up visual cues to complete the approach.

OBJECTIVES

1. Identify and evaluate flyability problems on a back course approach with a glide slope.

2. Determine the point at which the elect.onic guidance is no longer usable (flyable).

3. Establish obstacle clearance criteria for the ILS back course approach with glide slope.

TEST METHODS

Simulator Phase. The simulator phase was designed to evaluate flyability problems under all possible combinations of facility guidance and receiver modes and to identify a tentatively acceptable decision height for evaluation during the flight phase.

The Boeing 707 simulator was used to record localizer and glide slope tracks on simulated approaches to Minn.-St. Paul rwy 4 (front course ILS) and rwy 22 (back course ILS wi' glide slope). See Figure 1, Page 3.

The approaches were flown as published except that all approaches were simulated to a decision height of 100'. This DH tested the following assumption:

> If the flyability of a back course with glide slope is acceptable, both localizer and glide slope must provide usable precision guidance to an authorized decision height. (Precision guidance was considered unusable with full scale deflection of either cross-pointer needle or needle movement too rapid for normal correction technique to follow.)

Simulator subjects were seven FAA Air Carrier instructor pilots, qualified and current in the Boeing-720, as well as one additional pilot with only familiarization training in the aircraft.

Flight Phase. The FAA Chickasha ILS was engineered for the flight phase to provide back course approach with glide slope by remounting the glide slope antenna on the back side of the antenna mast used for the front course approach. OM and MM signals were simulated over ground check points through a manually controlled marker beacon light. Flight check of this facility configuration showed both localizer and glide slope within flight inspection tolerances.

An approach procedure was developed (CHK Back Course ILS Rwy 35, attached), to present a flyability situation approximating the one on Minn.-St. Paul Back Course ILS Rwy 22. See Figures 2, 3, and 4, Pages 4, 5, and 6.

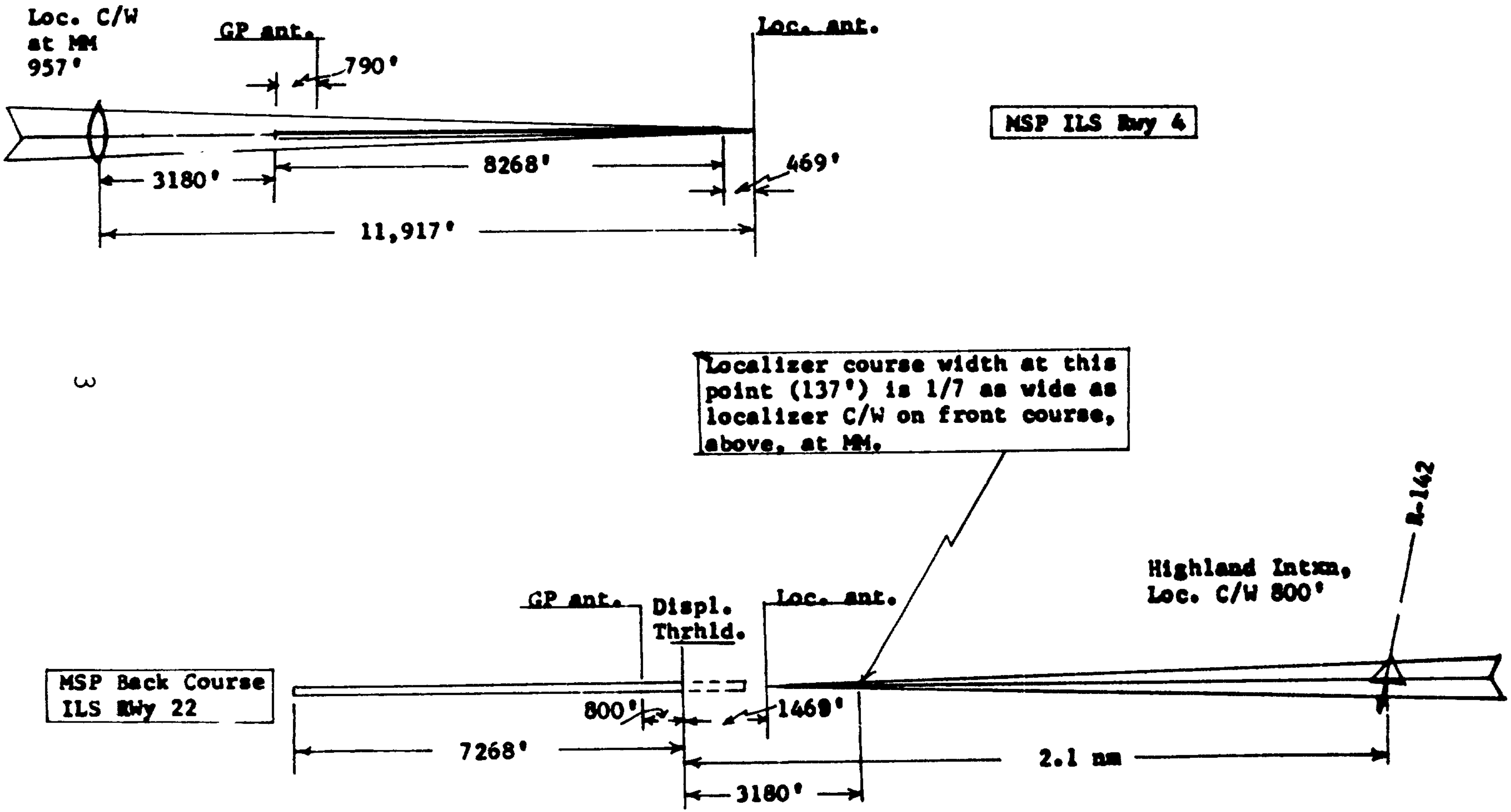
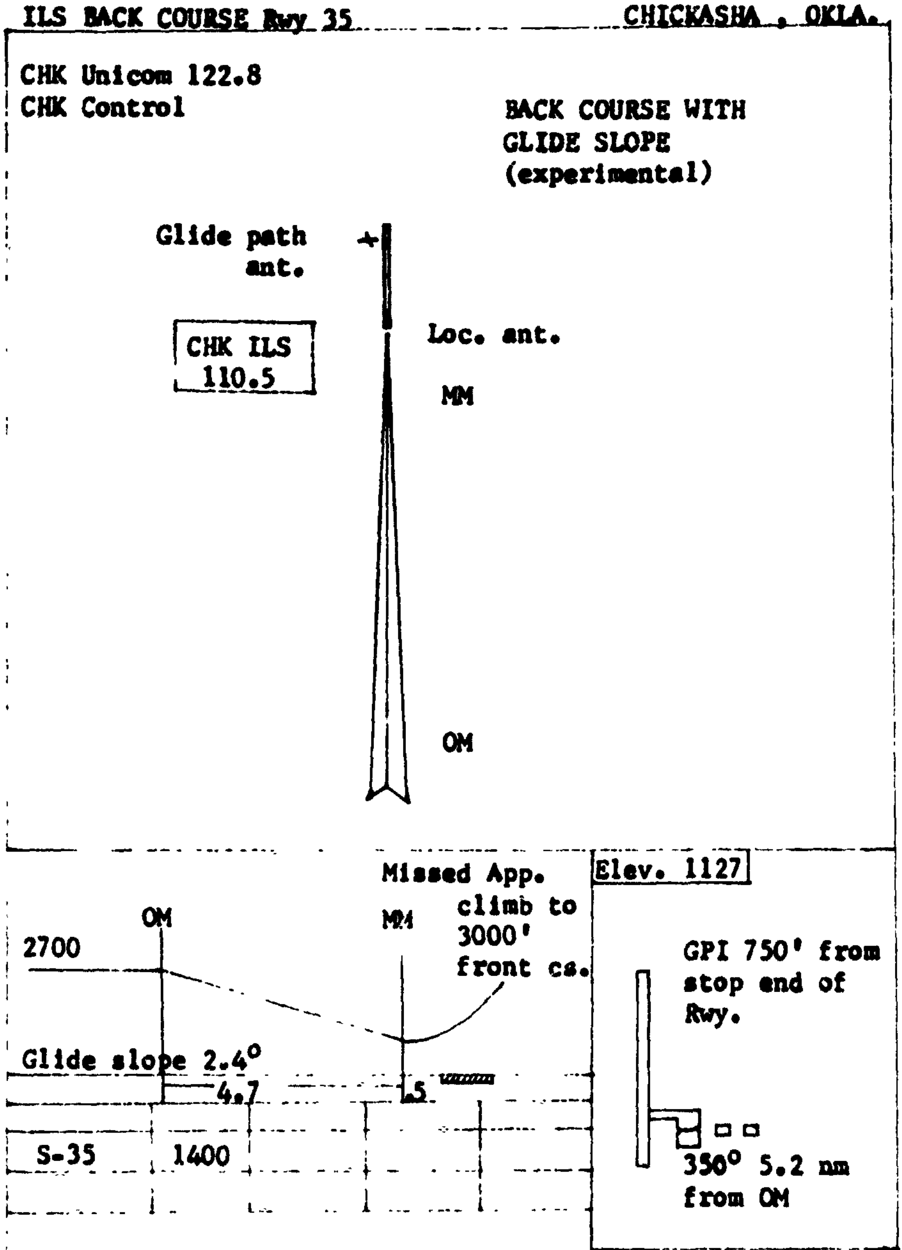


Figure 1. ILS Course Comparison. MSP Rwy 04 & 22.

ILS BACK COURSE Rwy 35 — CHICKASHA, OKLA.



KNOTS	90	100	110	120
time	3:24	3:05	2:50	2:36

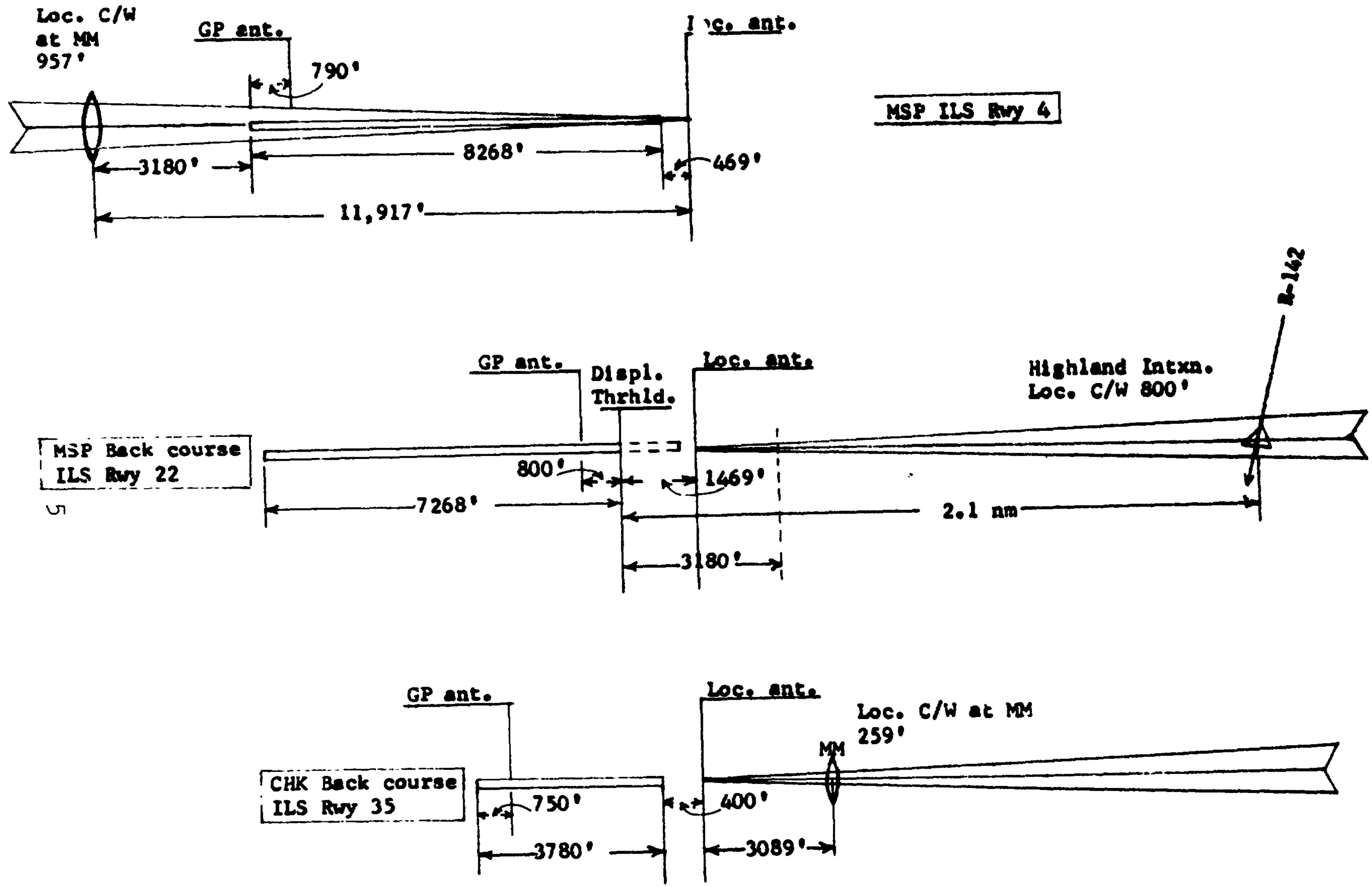


Figure 3. ILS Course Comparison.

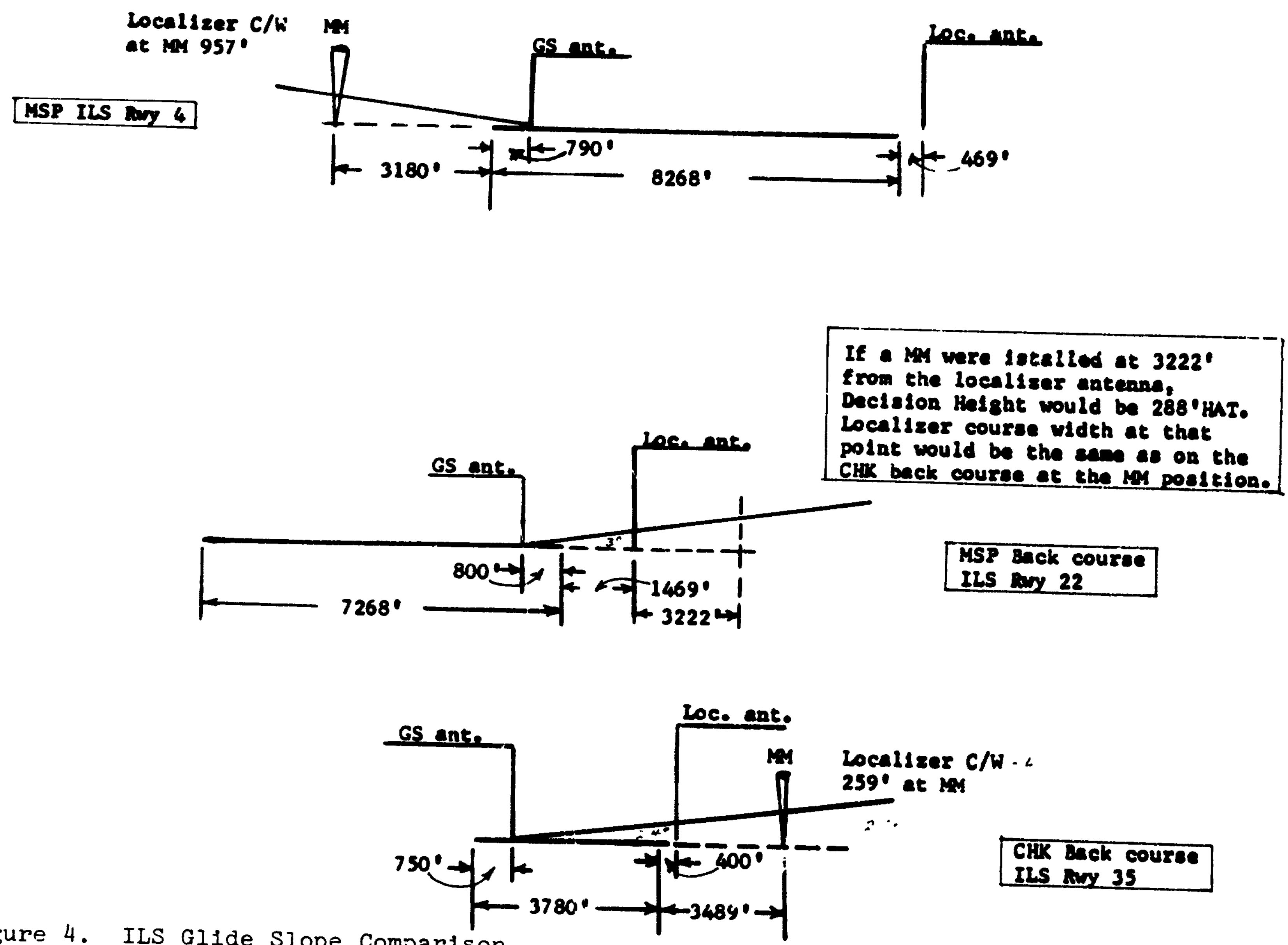


Figure 4. ILS Glide Slope Comparison.

On each back course approach, the safety pilot vectored the subject pilot to intercept the final approach course inbound at approximately 8 miles from the approach end of the runway and cleared him for the low approach. The subject's only additional flight task was to notify the safety pilot if and when he found elevation or azimuth guidance, or both, either disorienting or unusable at any point during the approach. The decision height and MDA established for the approaches was based upon examination of simulator data previously collected and on the location of a check point used for simulating the MM position. No serious flyability problems had been encountered in the simulator when the back course was flown presumably under the most difficult of the receiver modes tested; namely, localizer with glide slope, reverse sensing, and raw data. Of the 8 pilots who flew this simulator approach, one lost localizer guidance at 310' HAT. The remaining seven flew to 210' HAT or below without loss of either localizer or glide slope guidance. Accordingly, a decision height of 269' (1400 MSL) was selected for the flight phase as being within the capability of the subject pilots. This height coincided with a known landmark which afforded a measurement capability. It also approximated as closely as practicable the minimum HAT (250') allowed in TERPs for localizer-only approaches.

The CHK back course approaches were normally flown to this DH or MDA. (269 feet).

Since all of the approaches were conducted under tailwind conditions, the missed approach was normally initiated at the MM position (269' HAT) to avoid conflict with opposing traffic. When conditions permitted, however, unscheduled additional approaches were flown in the B-55, Learjet, and Sabreliner to reported decision heights as low as 160' without loss of either localizer or glide slope guidance. These approaches below 269' HAT were not included in reduced data due to unreliability of measurement techniques beyond the known landmark, and because of the small sample size.

For comparison of back and front course ILS flyability, several pilots additionally flew the published front course ILS approach to Will Rogers Airport.

Three light twin aircraft, a DC-3, three executive jet twins, and a Boeing-720 were used for the flight evaluation. Twenty-three FAA subject pilots, qualified and current in their respective aircraft, flew simulated back course ILS approaches on the Chickasha facility, with and without glide slope guidance, and with both normal and reverse localizer sensing.

DATA COLLECTION

Simulator Phase (Boeing-707)

Each subject pilot flew the following sequence of approaches for flyability comparisons:

Run #	Facility & Type of Approach	Receiver mode
1	Front course, loc. & GS	flight director
2	Front course, loc. & GS	raw data
3	Back course, loc. only	reverse sensing, raw data
4	Back course, loc. only	normal sensing, raw data
5	Back course, loc. & GS	reverse sensing, raw data
6	Back course, loc. & GS	normal sensing, raw data
7	Front course, loc. only	flight director
8	Front course, loc. only	normal sensing, raw data
9	Front course, loc. only	reverse sensing, raw data

On each approach, flight track data were taken on a glide path recorder and an X-Y approach recorder. On each run, the subject pilot reported the point at which he lost either glide slope or localizer guidance, and the recordings were marked at that point. Lost guidance was considered to be full-scale deflection of either localizer or glide slope needle.

Recorded flight track data were supplemented by a pilot opinion questionnaire completed after the simulator exercise. Sample questionnaire is shown in Appendix, Page A-1.

Note: The Flight Director was the Collins FD-108, which permitted pilot selection of various guidance conditions required for flyability comparisons. In the raw data mode, the computer function was not used; guidance was essentially the same as provided by the standard cross-pointer, with reverse or normal localizer sensing selected by the pilot.

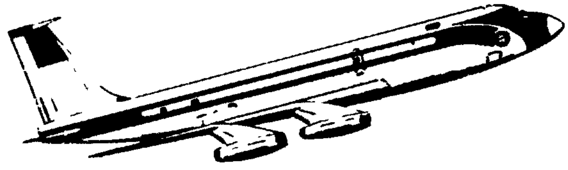
Flight Phase

Each subject pilot flew a "localizer only" approach and three localizer with glide slope approaches on the Chickasha back course ILS. On the DC-3 runs, azimuth, elevation, and range data were collected on flight inspection Century recorders. In the Light Twin and Executive Jet aircraft, the subject pilots' instrument panels were photographed at 5 second intervals during the approaches. On all Chickasha approaches, the project engineer recorded the altimeter reading when the subject pilot reported loss of either glide slope or localizer guidance. Runs flown on the published front course approach to Will Rogers World Airport were not recorded, nor were the runs flown in the Boeing 720.

Flyability of the back course ILS with glide slope had already been evaluated in the Boeing-707 simulator. The flight evaluation was conducted to check the points in heavy jet aircraft where navigational guidance would be lost.

The tabulation on the following page shows the aircraft, number of subject pilots, and navigational guidance used during the flight phase of the project.

Subject pilots completed the same questionnaire used during the simulator phase. (See Appendix, Page A-1)



Type Aircraft	Number of subjects	Receiver mode used	Number of runs	
			Loc. only	Loc. & Glide Slope
Beech Baron	6	raw data (reverse loc. sensing)	6	18
Beech 99	2		2	6
Cessna 402	2		2	6
DC-3	5		5	15
Sacreliner	2	raw data with normal sensing. loc. & glide slope	2	6
Learjet-24	2	3 runs with normal sensing. 5 runs with reverse sensing.	2	6
Jet Commander	2	2 runs with normal sensing. 6 runs with reverse sensing.	2	6
Boeing 720	2	raw data - normal sensing all runs.	2	6
	23		23	69

Figure 5. Tabulation of Data.

DATA REDUCTION AND ANALYSIS

Simulator Phase

Azimuth and elevation recordings from the nine types of simulator approaches were examined for evidence of flyability problems. Regardless of the receiver mode used on the five front course approaches, none of the six pilots type rated in the B-720 reported unusual flyability problems. Runs flown with flight director guidance were most accurate,as expected, since this mode is normally used by the subject pilot group. The last two of the nine runs scheduled for each subject were front course "localizer only" approaches, with raw data guidance. Selection of reverse localizer sensing had no apparent effect on the flyability of the front course, due to cuing inherent in the test situation and to practice during previous runs.

Composites of each type of back course approach and of one front course approach were produced from the simulator recordings to show azimuth and elevation comparisons under the following guidance conditions: (See Pages 12 through 19)

- Front course, localizer & glide slope, raw data.
- Back course, localizer only, reverse sensing, raw data.
- Back course, localizer only, normal sensing, raw data.
- Back course, loc. & glide slope, reverse sensing, raw data.
- Back course, loc. & glide slope, normal sensing, raw data.

Comparisons of flight tracks of "localizer only" approaches, Fig. 8, 9, 10, & 11, reflect initial problems with reverse sensing, probably due to the fact that this mode is an abnormal use of the Integrated Flight System, customarily flown with normal sensing on both front and back course approaches. Following a practice "localizer only" run with reverse sensing, the approach reported as the most difficult (back course with glide slope, reverse sensing) was flown with no serious flyability problem as compared with the other approaches. See flight track composites, Figs. 12 and 13.

For each of the back course approaches flown under four different guidance conditions, the points were identified on the recorder plots where usable guidance was lost. Guidance usable to 100' HAT was recorded as no loss of guidance. Fig. 14 is a tabulation of usable guidance data for the 32 back course approaches. Localizer guidance was lost before glide slope guidance on all approaches but one. On 8 of the 14 approaches with glide slope, flown by qualified and current pilots, guidance was usable to 100' DH. Guidance was usable to an average HAT of 147', with reverse localizer sensing, and to an average HAT of 143', with normal sensing.

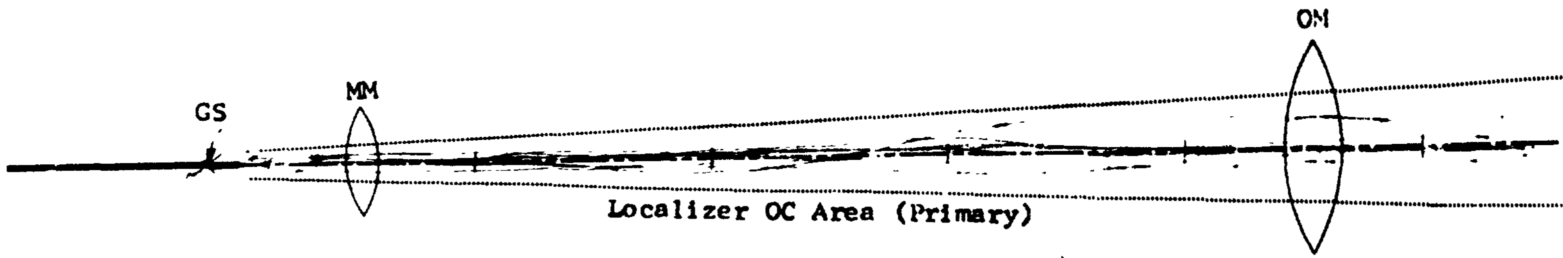


Figure 6. B720 Simulator Composite. LOC/GS. Raw Data. (Front Course). Localizer Plot.

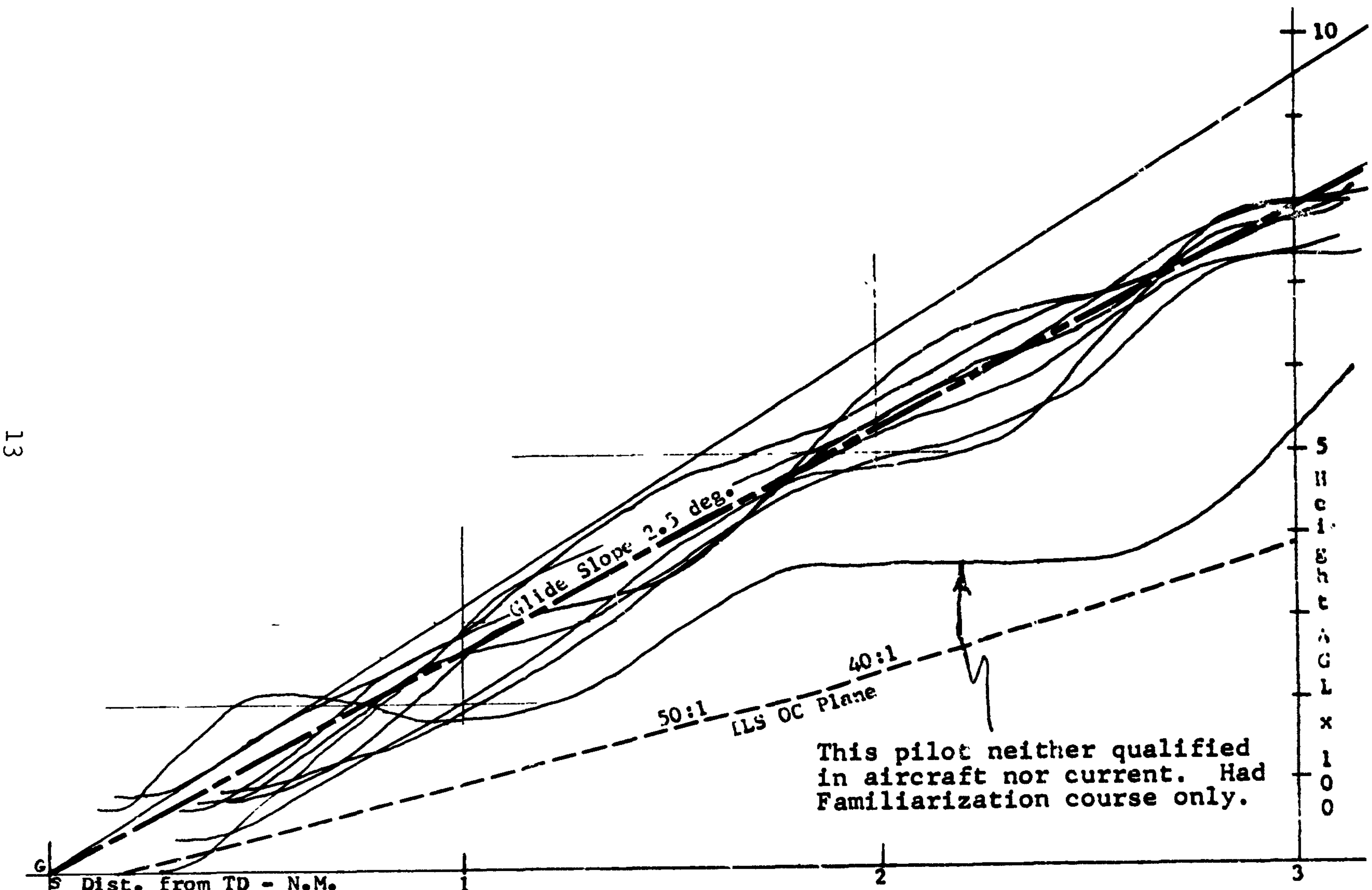


Figure 7. B720 Simulator Composite. LOC/GS. Raw Data. (Front Course) Glide Slope Plot.

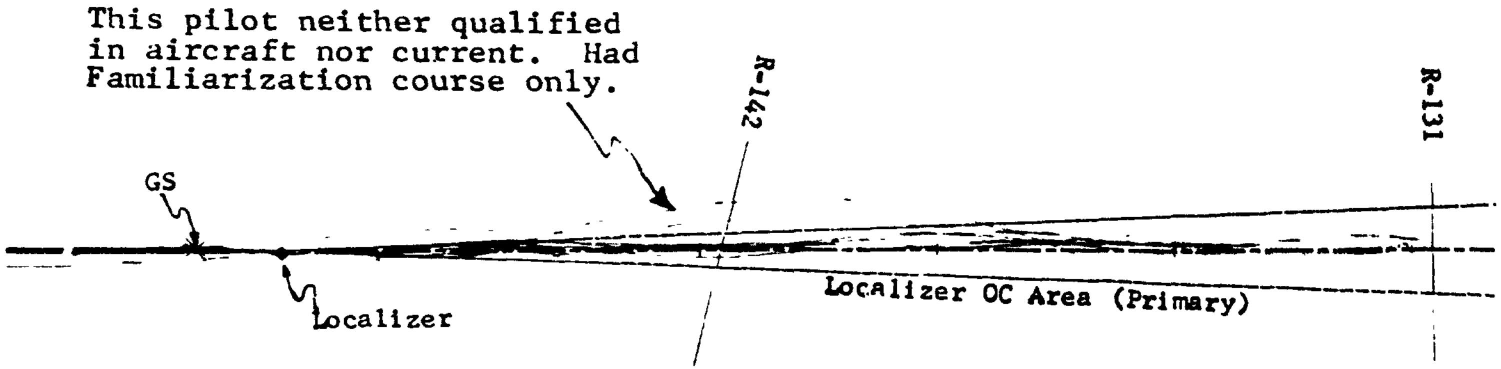


Figure 8. B720 Simulator Composite. LOC only. BC. Reverse. Raw Data. Localizer Plot.

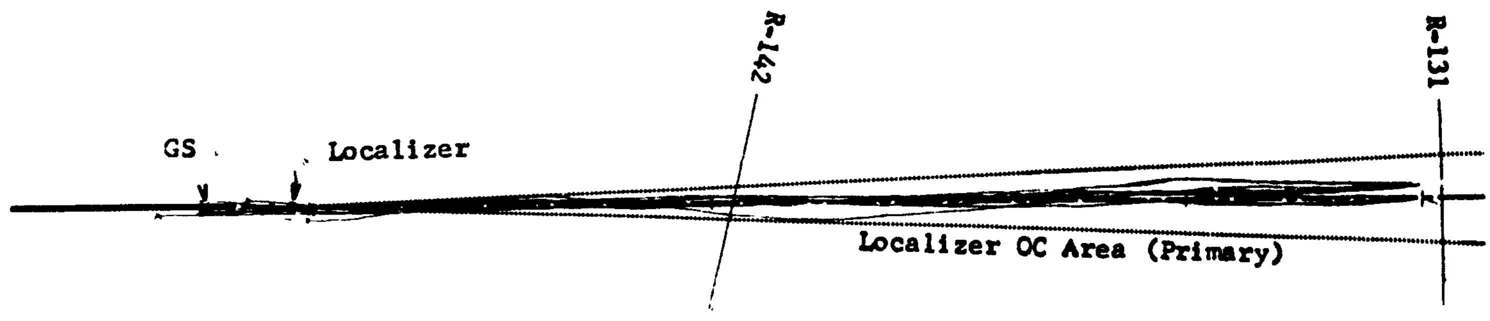


Figure 9. <u>B720 Simulator Composite</u>. LOC only. BC. Normal Sensing. Raw Data. <u>Localizer Plot</u>.

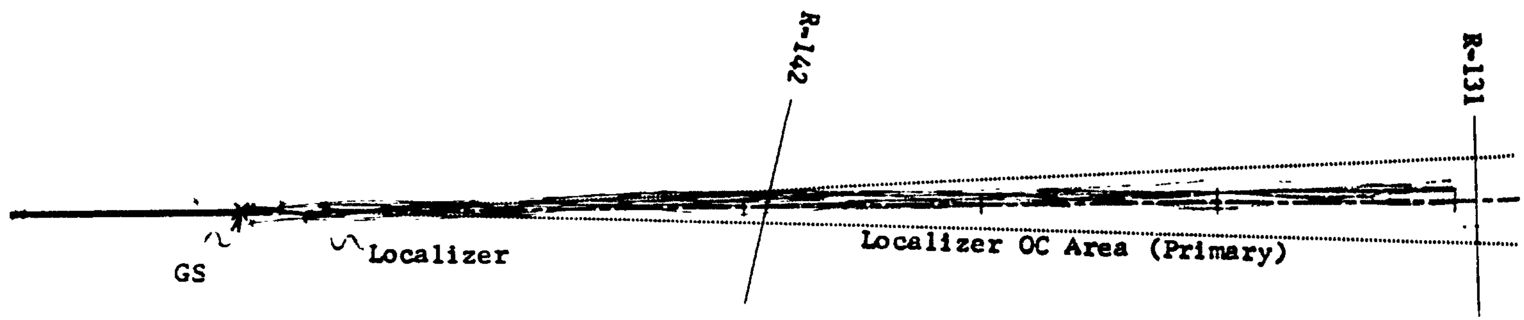


Figure 10. B720 Simulator Composite. LOC/GS. BC. Reverse Sensing. Raw Data. Localizer Plot.

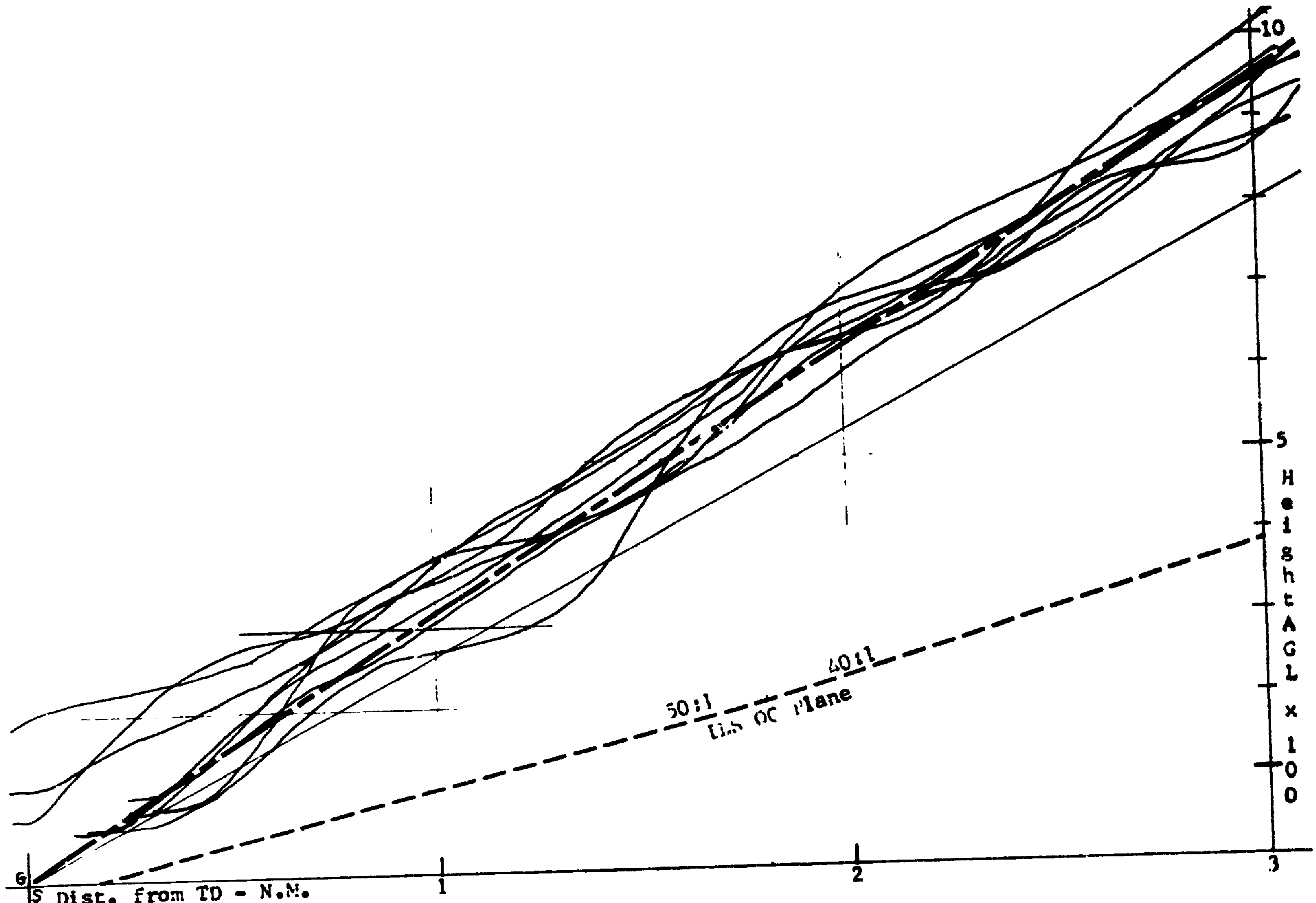


Figure 11. B720 Simulator Composite. LOC/GS. Reverse Sensing. Raw Data. Glide Slope Plot.

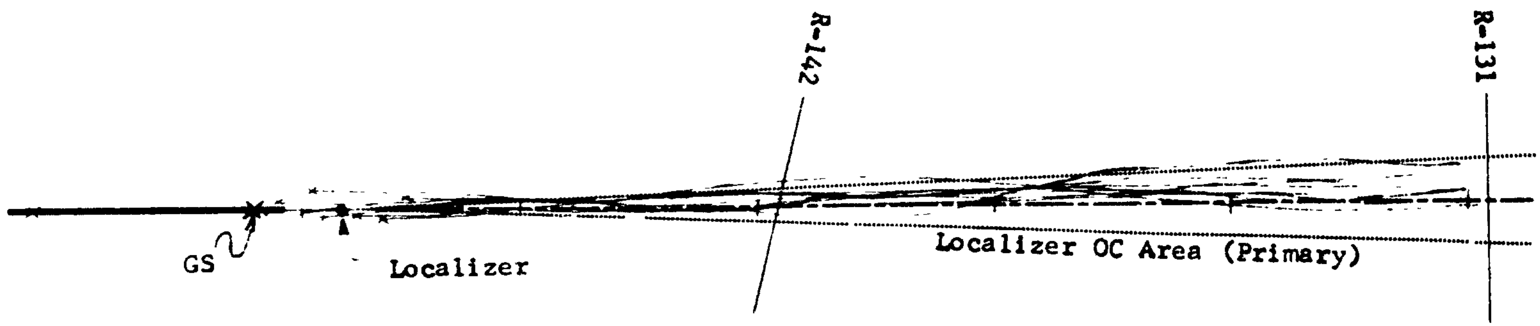


Figure 12. B720 Simulator Composite. LOC/GS. BC. Normal Sensing. Raw Data. Localizer Plot.

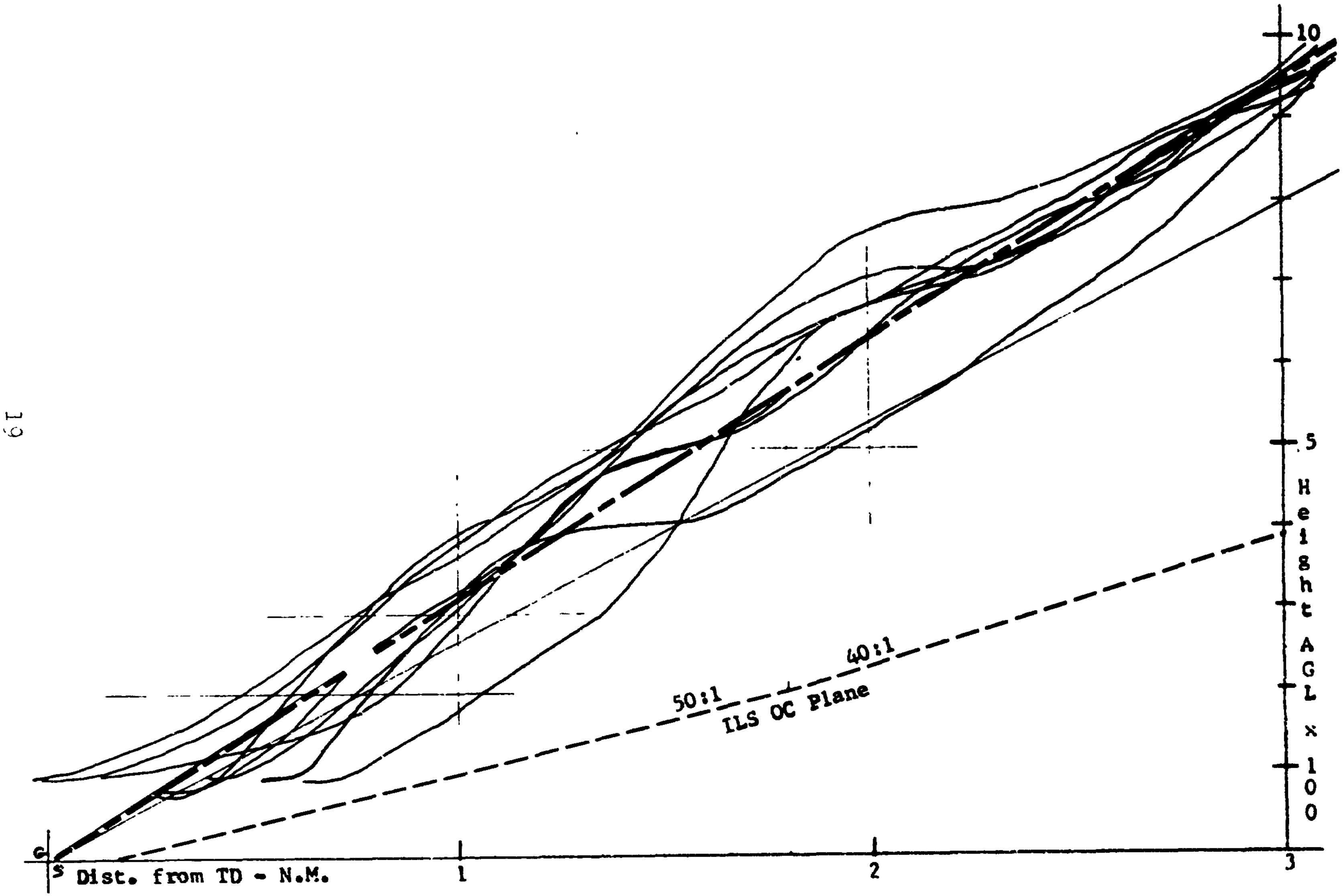


Figure 13. B720 Simulator Composite. LOC/GS. BC. Normal Sensing. Raw Data. Glide Slope Plot.

SIMULATOR DATA - Back course approaches - 8 pilots

Run #	Type Guidance	HAT & Dist. (nmi) from GPI where guidance lost.
1.	Back course	no loss to 100' MDA/.3nm-4 pilots
	Localizer only	120' - 0.86
	Reverse sensing	220' - 0.35
	Raw data.	630' - 0.86
		(320' - 0.20)*
2.	Back course	no loss to 100' MDA/.3nm -2 pilots
	Localizer only	400' - 0.60
	Normal sensing	200' - 0.32
	Raw data.	240' - 0.55
		180' - 0.70
		240' - 0.54
		(560' - 1.30)*
3.	Back course	no loss to 100' DH - 4 pilots
	Localizer and	310' - 0.80
	glide slope	110' - 0.32
	Reverse sensing	210' - 0.19#
	Raw data.	(180' - 0.21)*
4.	Back course	no loss to 100' DH - 4 pilots
	Localizer and	180' - 0.63
	glide slope	160' - 1.23
	Normal sensing	260' - 0.94
	Raw data.	(810' - 2.79)*

* Pilot not type-rated in Boeing-720; familiarization training only.

\# Glide slope guidance lost. All other lost guidance figures refer to localizer guidance.

Figure 14. B720 Simulator Tabulation. All Data.

DATA REDUCTION AND ANALYSIS

Flight Phase

Azimuth, elevation, and range data were extracted from flight recorder tracks of DC-3 back course approaches to plot aircraft position from the Middle Marker to the Outer Marker at 1 mile intervals.

For the light twin and executive jet aircraft, position data were extracted from photographs of the ILS indicators. This glide slope and localizer data was combined with known speed/elapsed time information and localizer/glide slope dimensions to extrapolate aircraft position at the selected data points.

Two scatter plots were drawn showing aircraft position at six data points from MM to OM on the back course approach with glide slope and on the "localizer only" approach. Each composite represents one approach by each of the light twins, executive jets, and DC-3. See Figs. 15 and 16(Pages 24 and 25)

For each approach on the back course with glide slope, the point where the pilot reported lost guidance was determined in terms of height above touchdown, extrapolated from the recorded altimeter reading. The average HAT to which guidance was usable was then computed for each aircraft type, as shown in Fig. 17. 71% of the approaches flown in light twin, executive jet, and DC-3 aircraft reported usable to the Middle Marker, with flyability improving on successive approaches. In all instances, guidance reported lost was localizer guidance.

Back course approach, Chickasha ILS
Localizer only (3 light twin, 3 exec. jet, 1 DC-3 aircraft) Aircraft position about the localizer course, MM to OM at 1 mile intervals.

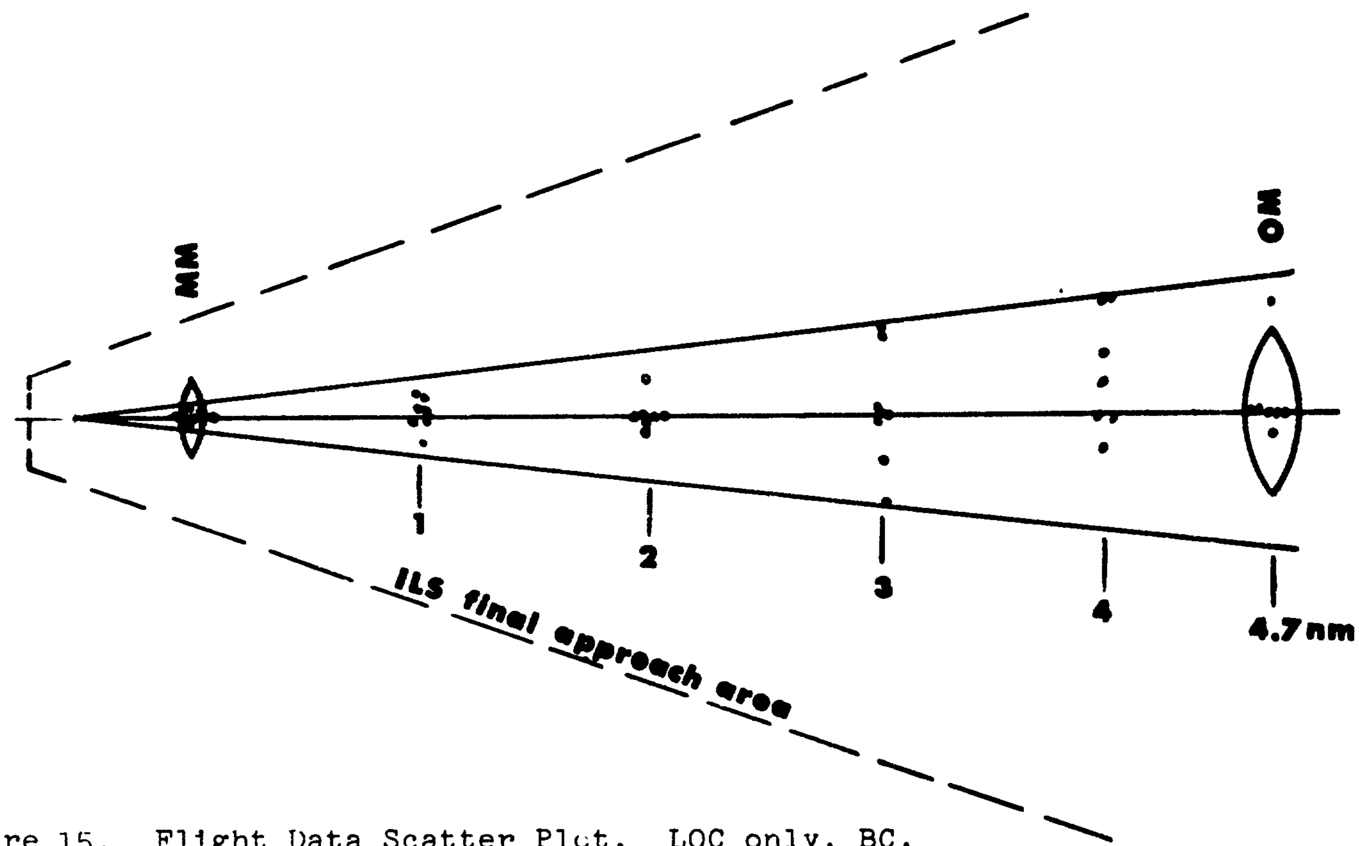


Figure 15. Flight Data Scatter Plct. LOC only. BC. Localizer Plot.

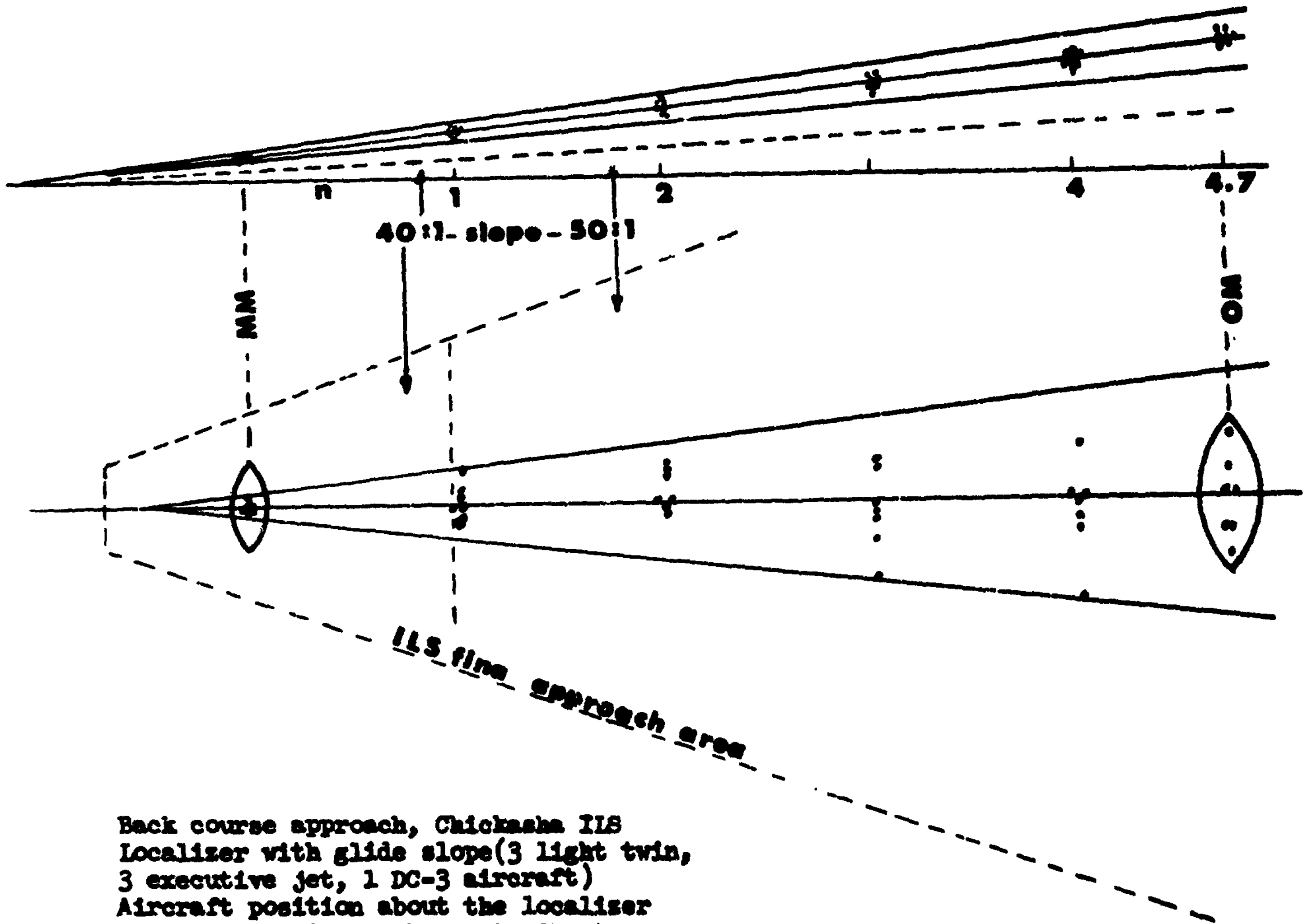


Figure 16. Flight Data Scatter Plot. LOC/GS. BC. Localizer and Glide Slope Plot.

FLIGHT DATA - Back Course with Glide Slope

Approaches flown with Reverse localizer sensing

Type aircraft	Number of approaches	Avg. height above touch-down guidance was usable			Average HAT all approaches
		1st apch	2nd apch	3rd apch	
Beech 55	18	353'	288'	278'	306'
Cessna 402	6	395'	350'	270'	338'
Beech 99	6	270'	290'	270'	278'
DC-3	15	342'	285'	274'	300'
Lear	4	294'	285'	--	290'
Commander	4	325'	270'	--	298'

Approaches flown with normal localizer sensing

Lear	2	270'	--	--	270'
Commander	2	280'	--	--	280'
Sabreliner	6	270'	315'	270'	285'

All approaches, normal and reverse sensing

Light twin	307'
Executive jet	287'

Figure 17. Flight Data Tabulation.

PILOT QUESTIONNAIRE - Back Course ILS Project

Write an "X" in the box opposite the answer you select.

1. Of the 3 types of approach flown, which was the most difficult?
   the least difficult?

M	L	
☐	☐	ILS B/C with Loc. only.
☐	☐	ILS B/C with glideslope.
☐	☐	ILS front course.
☐		No appreciable difference among the three.

2. Of the 3 types of approach flown, which do you think you fly most accurately?

   ☐ ILS B/C with Loc. only.

   ☐ ILS B/C with glideslope.

   ☐ ILS front course.

   ☐ No appreciable difference among the three.

3. Were you aware of any vertical or lateral disorientation at any time on the ILS B/C with glideslope?

Yes	No	
☐	☐	Loc. only.
☐	☐	Loc. and glideslope.

4. Where did you experience disorientation?

   ☐ During localizer intercept.

   ☐ Glideslope intercept.

   ☐ Approaching MAP.

   ☐ At no time.

5. Would you expect, under actual instrument conditions, to experience any problems in flying a published BC ILS approach with glideslope?

   ☐ Yes ☐ No

6. If your answer to #5 above, is Yes, explain the conditions under which you would fly a B/C ILS with glideslope. (Radar monitoring, crew, or equipment requirements). Answer on reverse side.

QUESTIONNAIRE DATA SUMMARY

The summary of questionnaire responses by 29 pilots in simulator and flight phase is given below. 41% of the subjects considered the back course with glide slope the most difficult to fly of the types of guidance tested. 31% stated no difference in difficulty between front and back course systems. 93% reported no disorientation on the back course with glide slope. 74% of the subjects expressed unqualified confidence in their ability to fly the back course with glide slope under instrument weather conditions. The rest of the group recommended precautionary actions as expressed in the summary of comments under item 6, below.

1. Of the 3 types of approaches flown, which was the <u>most</u> difficult? the <u>least</u> difficult?

	ILS BC with glide slope	ILS BC loc. only	ILS front course	No difference
Most diff.	12	8		9
Least diff.	1	1	18	

2. Of the 3 types of approaches flown, which do you think you fly <u>most</u> accurately?

ILS BC with glide slope	ILS BC loc. only	ILS front course	No difference
1	1	21	6

3. Were you aware of any vertical or lateral disorientation at any time on the ILS back course with glide slope?

Localizer only		Localizer with glide slope	
Yes	3	Yes	2
No	26	No	27

4. Where did you expe[illegible]ce disorientation?

During locali[illegible] intercept	2
Glide slope i[illegible]cept	
Approaching M[illegible]	3
At no time	24

5. Would you expect, under actual instrument conditions, to experience any problems in flying a published BC ILS approach with glide slope?

Yes 6 No 23

6. If your answer to #5 above is "yes", explain the conditions under which you would fly a back course ILS with glide slope.

(B-720) 3 subjects recommended radar monitoring. One recommended a distinctive AL Chart to prevent confusion in reading front and back course information; also suggested training and certification on the system for all users.

(B-55) "I like all the help I can get on <u>any</u> instrument approach. A glide slope, front or back course, is help. So are radar and co-pilot."

(B-55) If the suspected problem is "reverse sensing", it's less of a problem than no precision guidance at all. Instrument scan is much easier with vertical and horizontal guidance, with or without "reverse sensing" on one instrument; localizer sensitivity is the real problem, which the right minimums should take care of.

(C-402) Considering fatigue, distractions, heavy wx, etc., I would feel more comfortable with radar monitoring on this type approach.

(C-402) AL Chart should make a very prominent distinction between front and back course approaches with glide slope. Also, the approach should be radar monitored, with a precautionary statement from the Approach Controller on approach clearance, such as: "repeat, this is a back course approach."

FINDINGS

1. Flyability. Since localizer guidance was lost before glide slope guidance in all but one instance during both simulator and flight phases of the project, the difficulty in flying the back course with glide slope can be attributed primarily to localizer sensitivity associated with the narrow course. Confusion or disorientation expected to result from a combination of normal and reverse cross-pointer sensing was not considered a significant factor by the majority of the subjects.

2. Lowest Usable Height above Touchdown on ILS Back Course with Glide Slope. If the lowest usable HAT is predicated

   a. If the lowest usable HAT for any given glide slope angle is predicated on the availability of navigational guidance, then the parameter controlling HAT is localizer sensitivity. HAT averages are thus a function of localizer course widths at the heights indicated.

   b. The usable guidance averages found during the flight phase are shown below. These are also depicted in terms of localizer course widths at the various HATs in the evaluation and the distances from the localizer antenna.

Acft	HAT	LOC Width	Antenna Dist
Light Twin	307'	326'	3895'
Exec Jet	287'	286'	3415'
DC-3	300'	313'	3728'
B-720	330'	373'	4445'

3. Criteria. None of the back course ILS approaches with glide slope, flown by qualified pilots in the simulator and flight evaluations, with the least favorable receiver mode (reverse localizer sensing, normal glide slope sensing, raw data), penetrated the vertical and lateral obstacle clearance limits established for the standard Cat I ILS. Obstacle clearance criteria for the Cat I front course appears to be adequate for the back course system evaluated, assuming that the glide slope antenna is installed at a standard location.